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of

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for

**BRIDGE CIRCUIT TO SUPPRESS ECHOES
IN COMMUNICATION DEVICES**

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BRIDGE CIRCUIT TO SUPPRESS ECHOES IN COMMUNICATION DEVICES

[001] This application claims priority to and the benefit of German Patent Application No. 102 47 208.4, filed on October 10, 2002, and entitled "BRIDGE CIRCUIT TO SUPPRESS ECHOES IN COMMUNICATION DEVICES," which is incorporated herein be reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[002] The present invention relates to circuits for communication devices. More particularly, the invention relates to a bridge circuit to suppress or damp echoes in communication devices.

2. Background Technology

[003] In duplex mode, with a two-wire line, signals are transmitted simultaneously in both directions from and to a communication device, for example an xDSL modem. In order to be processed further, the incoming and outgoing signals must, however, be separated at both line ends into their respective transmission directions. Conversion therefore takes place from two-wire transmission to four-wire transmission and vice versa, performed by a hybrid circuit, for example.

[004] Figure 3 shows diagrammatically such an arrangement. Transmission and reception signals c are transmitted together on a two-wire line 4 from and to a remote end 5 of the line 4. At the near end of the line a hybrid circuit 6 performs the conversion from two-wire transmission to four-wire transmission. The transmission

signal a is supplied to the hybrid circuit 6 at a connection 1 for a transmitter device, and the reception signal b is tapped or picked up at a connection 2 for a receiver device.

[005] The problem arises here that the transmission signal a is reflected as an echo d into the reception signal b. Depending on the line type, the signal power of this echo can far exceed that of the reception signal. Hybrid circuits and/or filter solutions are designed to suppress this echo as far as possible.

[006] A known possibility for echo suppression is the use of passive or active filters. This type of echo suppression has the advantage that the filters can be dimensioned independently of the transmission line. Depending on the transmission system used, these filters may, however, be very complex and hence cost-intensive. A further disadvantage of filter solutions is that the filters must be adapted accordingly for transmission and reception frequency bands that differ by system, which *e.g.*, is possible only to a limited extent for integrated solutions.

[007] Another solution approach is intended to simulate the echo path and cancel the echo with a signal obtained by simulation. This approach is generally known as Echo Cancellation. Examples of this are so-called balancing filters or 2nd DAC (digital-analog converter) solutions. The advantage of this method is the great independence of the frequency bands used.

[008] Both solutions can be designed to be relatively easily programmable, but are critical elements in the overall system in view of their linearity and noise contribution. The reason is that the echo suppression takes place first at the corresponding receiver or semiconductor module. After this suppression a great amplification is required to utilize the maximum signal level of the analog-digital converter (ADC) present in the reception signal path of such circuits.

[009] Another possibility for echo cancellation is resistive or complex termination sets or bridge circuits. These circuits are dimensioned so that they simulate as well as possible a particular area of line types. Because of the various possible line properties it is necessary to make compromises in dimensioning and thus not obtain good echo suppression for every line type.

[010] Figure 4 shows the principle structure of a simple hybrid in the form of a bridge circuit. A combined transmission and reception signal c is transmitted via a transmitter 7 to the bridge circuit. The transmission signal a is supplied via a connection 1 to a transmission device, and the reception signal b is tapped via a connection 2 for a receiver device. An impedance Z1 can represent, for example, loads of a communication device comprising the bridge circuit, and an impedance Z2 can correspond to a winding in the transmitter 7 and serves to take into account the line impedance of the corresponding transmission distance or line. Impedances Z1 and Z2 are components of a first bridge branch of the bridge circuit. A second bridge branch formed from impedances Z3 and Z4 serves to simulate the path formed by Z1 and Z2 and thus balance the bridge circuit. The echo is minimized if equation 1

$$\frac{Z1}{Z2} = \frac{Z3}{Z4} \quad (1)$$

is fulfilled. The transmission function of the transmission signal on the line is not influenced by the adjustment and is not considered further here.

[011] In these circuits the problem arises that such a circuit cannot be implemented in an integrated circuit as the signal level in the second bridge branch is generally very

high, although the signal power only amounts to a fraction of the transmission power as the second bridge branch is generally designed to have a high impedance.

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SUMMARY OF THE INVENTION

[012] The present invention is directed to a hybrid circuit, present in the form of a bridge circuit, which is programmable in a particular range and implementable at least partly in the form of an integrated circuit. This invention features are achieved by a bridge circuit having the features described herein.

[013] According to the invention, to balance the bridge circuit a variable simulation device is provided to simulate at least one bridge branch or at least one bridge branch of circuit sections. The bridge circuit is thus not balanced or not balanced only by a change in impedances in one of the bridge branches of the bridge circuit, but by adapting the simulation device or the simulated bridge branches or circuit sections of the bridge circuit implemented thereby.

[014] This simulation device in particular can be designed and connected with at least one bridge branch so that a lower signal level is present therein than in the at least one bridge branch. Thus, the simulation device can be designed to be programmable and in the form of an integrated circuit.

[015] The simulation device, generally of higher impedance than the simulated bridge branch or simulated circuit section, can be connected in parallel to an impedance present in the at least one bridge branch. The bridge circuit generally also comprises impedances which are formed by a winding of a transmitter coupled with the relevant transmission line, a line impedance of the transmission section, or by loads present in a communication device comprising the bridge circuit.

[016] The invention is suitable preferably for use in an xDSL transmission system, for example VDSL or ADSL transmission systems, without however being restricted to this preferred area of application.

[017] These and other features of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set forth hereinafter.

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BRIEF DESCRIPTION OF THE DRAWINGS

[018] To further clarify the above and other advantages and features of the present invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention is explained in more detail below with reference to the enclosed drawings, wherein:

[019] Figure 1 shows one embodiment of a bridge circuit according to the invention;

[020] Figure 2 shows a second embodiment of a bridge circuit according to the invention;

[021] Figure 3 shows a diagrammatic view of a 2-wire/4-wire conversion; and

[022] Figure 4 shows a bridge circuit according to the state of the art.

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DETAILED DESCRIPTION OF THE INVENTION

[023] In the bridge circuit according to the invention shown in Figure 1, a combined transmission and reception signal *c* is coupled with a bridge circuit via a connection 3 for a transmission section and a transmitter 7. Supplied to this bridge circuit via a connection 1 is a transmission signal *a* for a transmitter device, and at a connection 2 a reception signal *b* is tapped for a receiver device.

[024] The bridge circuit includes a first bridge branch, formed by impedance *Z*₁, which for example represents loads of a communication device comprising the bridge circuit or serves for power adaptation, and an impedance *Z*₂ that shows the impedance of the transmission line and in the embodiment shown is implemented by a winding of the transmitter 7, and a second bridge branch. This second bridge branch includes impedances *Z*₃, *Z*₄, and *Z*₅. A variable or adjustable simulation device 8 is connected in parallel to the impedance *Z*₅. One pole of the connection 2 for the receiver device is tapped at the simulation device 8, and another pole of the connection 2 is tapped between the impedances *Z*₁ and *Z*₂. The simulation device which simulates impedance *Z*₅, as shown by balancing parameter *k*, can be modified so that the echo is minimized. This is the case if equation 2

$$\frac{Z_1}{Z_2} = \frac{Z_3 + k \cdot Z_5}{Z_4 + (1 - k) \cdot Z_5} \quad (2)$$

is fulfilled, where *k* lies in the closed interval of 0 to 1. The balancing parameter *k* can be determined via a suitable algorithm, which for example can use as an input a measurement of the echo signal level.

[025] By introducing impedance Z_5 , in comparison with the state of the art explained above and shown in Figure 4, a reduction in the signal level is achieved in the simulation device 8. With this type of bridge circuit it is now possible to design the simulation device with such high impedance that a programmable impedance array can also be implemented in integrated form. Thus, for example in the case of VDSL transmission systems, the resistance of the simulation device can be between about 1 k Ω and about 4 k Ω , whereas the resistance of the simulated part of the bridge branch, for example, is just about 20 Ω .

[026] This embodiment constitutes a good compromise between adaptability for different load or line impedances (in the present embodiment, shown by Z_1 or Z_2), low signal power in the simulated path Z_3 to Z_5 , and an input path with minimum noise for the input signal.

[027] A further embodiment according to the invention is shown in Figure 2. This shows in principle a doubling of the bridge circuit shown in Figure 1.

[028] In the same way as the case shown above, a transmission and reception signal c is coupled with a double bridge circuit arrangement via a connection 3 for a transmission line and via a transmitter 7. Supplied to this double bridge circuit arrangement, as in Figure 1, is a transmission signal a via a connection 1 for a transmitter device and a reception signal b is tapped at a connection 2 for a receiver device.

[029] A first bridge branch of a first bridge circuit of the double bridge circuit arrangement is formed by an impedance Z_{11} and an impedance Z_2 , and a second bridge branch of this first bridge circuit is formed by impedances Z_{31} , Z_{41} and Z_{51} . Similarly a first bridge branch of a second bridge circuit of the double bridge circuit arrangement

is formed by an impedance Z12 and impedance Z2, and a second bridge branch of this second bridge circuit is formed by impedances Z32, Z42 and Z52.

[030] Impedances Z11 or Z12 can for example, in a similar manner to the impedance Z1 shown in Figure 1, represent loads on a communication device comprising a bridge circuit. The impedance Z2 represents the impedance of a winding of the transmitter plus a line impedance of the transmission line transformed according to the transfer ratio. A variable simulation device 8 taps accordingly at impedances Z51 and Z52; in this embodiment both poles of connection 2 for a receiver device are tapped at simulation device 8. The simulation device 8 which simulates impedances Z51 and Z52, as shown by a balancing parameter k , can be adapted so that the echo is minimized. In this case, the balancing parameter k is two-dimensional, $k = (k1, k2)$, where $k1$ indicates a part of the two-dimensional balancing parameter provided to balance the first bridge circuit and $k2$ a part provided to balance the second bridge circuit k , and both $k1$ and $k2$ lie in the closed interval between 0 and 1. The echo is optimally suppressed when both equations 3.1 and 3.2 corresponding to equation 2 are fulfilled.

$$\frac{Z11}{Z2} = \frac{Z31 + k1 \cdot Z51}{Z41 + (1 - k1) \cdot Z51} \quad (3.1)$$

$$\frac{Z12}{Z2} = \frac{Z32 + k2 \cdot Z52}{Z42 + (1 - k2) \cdot Z52} \quad (3.2)$$

[031] By introducing impedances Z51 and Z52, again a reduction in signal level is achieved in the simulation device 8, which can therefore be implemented in the form of

an integrated and programmable circuit. The balancing parameter k can be determined in a similar manner to the embodiment in Figure 1 described above.

[032] The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

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